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The nonlinear Zeeman and parastriction effects in luminescence spectra of $LiY_{1-x}Tm_xF_4$ ($0.02 \leqslant x \leqslant 1$) crystals

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Abstract

Splitting of the first excited $\Gamma_{34}^1(^3H_6)$ doublet state of Tm^{3+} ions in the $LiY_{1-x}Tm_xF_4$ crystals in external magnetic fields up to 5.5 T has been studied using measurements of luminescence spectra at low temperatures. In the magnetic field perpendicular to the S_4-symmetry axis of the crystal lattice, the splitting of the non-Kramers doublet is caused by the joint action of the nonlinear Zeeman effect and the piezospectroscopic effect related to parastriction. Experimental dependences of the doublet splitting on the magnetic field strength and direction are in good correspondence with the theoretical estimations obtained in the framework of the semiphenomenological crystal field model. It is shown that spectroscopic data present direct information on the forced magnetostriction in the basal plane of uniaxial Van Vleck paramagnets that contain non-Kramers rare earth ions. The measured concentration dependence of the doublet splitting can be explained by taking into account variations of the elastic constants with the concentration of Tm^{3+} ions.

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Keywords: Van Vleck paramagnets; Parastriction; Electron–lattice interaction; Crystal field; $LiYF_4$; $LiTmF_4$

1. Introduction

The magnetoelastic properties of lithium-lanthanide double fluorides $LiRF_4$ have been systematically studied both experimentally and theoretically from the late 1970s [1–3]. The titled crystals have a scheelite ($CaWO_4$) structure with the space group C_{4h}^6; the unit cell contains two magnetically equivalent lanthanide R^{3+} ions at sites with the S_4 point symmetry. Giant low-temperature forced magnetostriction (parastriction) in the Van Vleck paramagnet $LiTmF_4$ was discovered by Altshuler et al. [4]. Lattice strains achieve values of $\sim 10^{-3}$ in magnetic fields of 2–4 T perpendicular to the crystal symmetry axis. The

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